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Data-Driven Modeling for the Magnetic Field Prediction in Particle-Accelerator Magnets Based on Measured Electrical Parameters

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The precise modelling of magnetic fields in particle accelerator magnets is essential for optimizing their performance and ensuring the accurate control of particle beams. Traditional modelling approaches require extensive multi-physics simulations and electrical and magnetic measurements. In this study, we explore using data-driven artificial intelligence models to predict the magnetic field based on the magnet's voltage and excitation current. We conducted a case study to validate this approach using dipole and quadrupole magnets from the Super Proton Synchrotron (SPS) at CERN. The results demonstrate that AI-based models can achieve accuracy comparable to traditional measurement methods. Additionally, the flexibility of AI models allows for continuous learning as new data becomes available, further enhancing the dynamic control capabilities of particle accelerators. Future work will focus on refining the models, expanding their applicability to different types of magnets, and exploring their integration into accelerator control systems for real-time field adjustments and optimization.

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